INRIA's project-team Cortex: Computational Neuroscience

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Computational Neurosciences
BCI activities (bougrain@loria.fr)
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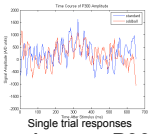
Overview

Our global activities concern (i) information analysis and interpretation and (ii) the design of numerical distributed and adaptive algorithms in interaction with biology and medical science. To better understand cortical signals, we use:
- a top-down approach: **data analysis techniques** extract properties of underlying neural activity.
- a bottom-up approach: a **mathematical neural modelling** aims for the understanding of experimental results.

The following activities are linked to Brain-Computer Interface challenges.

1. Modeling and detection of graphic-elements (evoked potential, spikes…) in single trials

We develop **algorithms** to extract event-related components from single trials based on:
- a Gaussian mixture model and implemented in a Bayesian framework.
- template-based classifiers [1]



Single trial responses

We evaluate our algorithms on a large Open-Access P300 Speller Database (**30 healthly subjects)** we codefined. This database has been recorded by the Neuroimaging Laboratory at Universidad Autónoma Metropolitana (UAM) and is freely available at: http://akimpech.izt.uam.mx/dokuwiki/doku.php

3. Winner of the BCI competition IV, datasets 4

We built a linear decoding scheme based on bandspecific amplitude modulation with a window to the past for predicting finger flexion from ECoG signals. The sensitivity profile of ECoG is clearly band-specific. The gamma band (60-100Hz) seems to provide more useful information (fig. 2). Only a few electrodes are necessary (fig.1)[2,4].

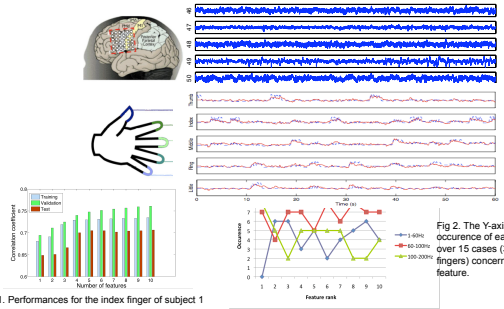


Fig 1. Performances for the index finger of subject 1

Fig 2. The Y-axis indicates the occurence of each frequency band over 15 cases (3 subjects x 5 fingers) concerning the selected feature.

2. Direct Brain-Machine Interfaces for the control of a skilled hand movement

- Decoding Finger Flexion from ECoG (see frame 3.)

- **Detection of LFP synchronization to study visio-motor feedback loop**.

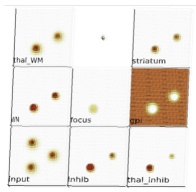
We investigate the synchronization of LFPs obtained intracranially from various monkey brain areas. The corresponding experiment combines visual attention and motor action. The data analysis [3] aims to detect time windows of increased phase synchronization between brain areas and relates these time windows to the monkey behavior.

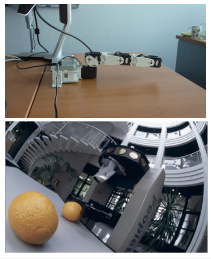
- **Cortical signals to control a two-finger robotic hand driven by artificial muscles**

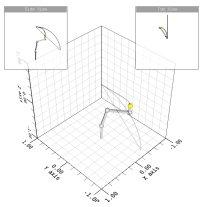
We study the control of two anthropomorphic fingers (index finger and thumb) using intra-cortical signals recorded in monkeys during grasping movements (precision grip), decoding both the position of the fingers and electromyographic activity (EMG) of muscles involved in movements of these two fingers.

4. Sensori-motor maps

A model of selective visual attention has been successfully implemented on a robot, endowed it with the ability to scan for different points of attention in a visual scene.







Projects

- STIC AmSud 2009-2010 : P300 single-trial detection
- CPER action 2009-2010 : P300-based BCI for children with motor disabilities
- CNRS NeuroInformatique 2010-2012 : Cortical signals to control a two-nger robotic hand driven by articial muscles
- CNRS NeuroInformatique 2009-2010 : sensory transduction to perception
- ANR MAPS 2008-2010 : spatial computation in sensori-motor maps
- ADT LOIC 2009-2010 with INRIA's project-team Bunraku:

We develop new applications, modules and drivers for OpenViBE

free open-source *OpenViBE* software
for Brain-Computer Interfaces and real-time neurosciences
(http:/openvibe.inria.fr)

References

[1] L. Bougrain. Template-based classifiers for ERP-based BCIs, in JAICC 2009, Argentine Paranà, 2009.
[2] N. Liang and L. Bougrain. Decoding Finger Flexion using amplitude modulation from band-specific ECoG, in ESANN, pp 467-472, 2009.
[3] A. Hutt and M. Munk. Detection of phase synchronization in multivariate single brain signal by a clustering approach, in Coordinated Activity in the Brain: measurements and relevance to brain function and behaviour, Springer, 2009.
[4] BCI competition IV, http://ida.first.fraunhofer.de/projects/bci/competition_iv/.